



Development of Video Exposure Monitoring (VEM) System and Training Program to Prevent Worker Exposure to Hazardous Agents.

**April 6th, 2018 – Presentation to GVSU Students and WMASSE and
WMIHS members.**

**James D. McGlothlin, MPH, Ph.D., CPE, FAIHA
Professor Emeritus – Purdue University
Founder and CEO of VEM Systems LLC**

Making an IH/Safety Case for using VEM as an Exposure Assessment Tool.



■ Outline of presentation:

• 1st hour (Part I):

- Making the Industrial Hygiene/Safety case for VEM
- Brief timeline for the development of VEM
 - NIOSH
 - Purdue University
 - VEM Systems, LLC
- Selected case studies (nested in the timeline of VEM development).
- Lessons learned?

• 2nd hour (Part II):

- Demo and Training Session (by Professors Dave Huizen and Jim McGlothlin, and one LUCKY GVSU student!).

Making the case for IH/Safety and Video Exposure Monitoring – an Exposure Assessment Tool.

- Very broad generalizations:
 - Ergonomics and Safety are linked,
 - Industrial Hygiene and Safety are linked,
 - Safety tends to be more focused on temporal (here and now) elements of work,
 - Health tends to be more focused on long-term elements of work.

Making the case for IH/Safety and Video Exposure Monitoring – an Exposure Assessment Tool.

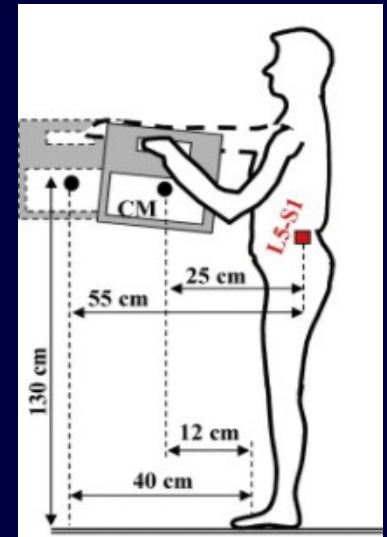
■ Very broad generalizations:

- Current safety tends to be more prevention oriented (machine guarding, power cut off systems, guard rails),
- Traditional Industrial Hygiene tends to be more intervention oriented (if exposure to hazard agents is over set limits, then mitigate – eliminate the agent, change the toxicity of the agent, improve ventilation). If not, no action taken.
- Ergonomics is both prevention and intervention oriented (use of models NIOSH RWL -to prevent musculoskeletal disorders; if work injuries are high – reduce weight, exposure).

Making the case for IH/Safety and Video Exposure Monitoring – an Exposure Assessment Tool.

■ Very broad generalizations:

- In some instances what works for occupational health is not recommended for occupational ergonomics/safety.
- Example #1: Manual handling of a hazardous chemical agent (such as a 50 lb. bag of sand to make cement - containing silica).
 - Industrial Hygiene prevention recommendation: hold the bag as far away from your body and breathing zone as possible.
 - Ergonomics/Safety: keep the bag as close to your body and breathing zone as possible to reduce excessive back stress and injury, and avoid blocking your view to reduce tripping hazards.



Making the case for IH/Safety and Video Exposure Monitoring – an Exposure Assessment Tool.

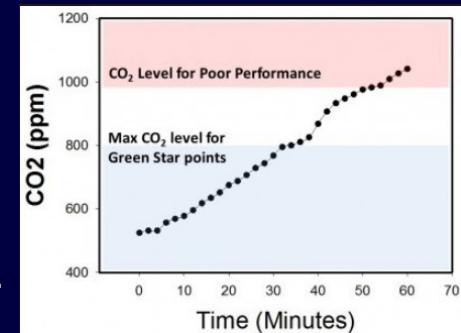


- **Example #2: Exposure to vapors and gases.**
 - Current project with Professor Dave Huizen at GVSU: Evaluation of Carbon Dioxide (CO₂) exposure in the manufacture of beer. Professor Huizen is looking at the interactions of physiologic demands, CO₂ levels, changes in heartrate, and biomechanical demands (back and shoulder disorders), of the job. His dissertation will simultaneously address safety, ergonomics and health on the job.

Making the case for IH/Safety and Video Exposure Monitoring – an Exposure Assessment Tool.



- Note: CO₂ is an asphyxiant, exposure to concentrations of 10 percent (100,000/ppm) or more of can **cause** death, unconsciousness, or convulsions. However, a recent Harvard study found “statistically significant and meaningful reductions in decision-making performance” in test subjects as CO₂ levels rose from a baseline of 600 parts per million (ppm) to 1000 ppm and 2500 ppm.*
- Our exhaled breath shows about 350 ppm of CO₂.
- It is not uncommon to find CO₂ levels in brewery's above 5,000 ppm (from yeast, but also purging vessels with CO₂).
- The CO₂ OSHA/NIOSH 8-hr limit is 10,000 ppm, for an 8-hour average, and 30,000 ppm for a 15 minute short term exposure.



Making the case for IH/Safety and Video Exposure Monitoring – an Exposure Assessment Tool.

■ Making the case for VEM:

- Use of VEM may address occupational health, safety and ergonomics challenges.
- I propose that:
 - The development of an instrument that can simultaneously video-record and link hazardous agent data, second by second, to show changes in exposure to hazardous agents can be used to identify opportunities to control and prevent illnesses, prevent musculoskeletal injuries, and prevent injuries and fatalities.

What is VEM?

- Video Exposure Monitoring (VEM) synchronizes real-time (or near real-time) chemical, biological radiological, and/or physical agent data with video recordings of workers and/or environmental activities.
- Does this technology remind you of anything else? Something that, if you are a science geek, had seen on TV.?

The Star Trek Tricorder has been brought to life with VEM Systems



<http://www.tricorderproject.org/>




open source hardware


the **Tricorder** project

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the Tricorder project is not affiliated with the Qualcomm Tricorder X PRIZE

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SEE WHAT'S POSSIBLE

TO BUILD A BRIDGE TO ABUNDANCE FOR ALL

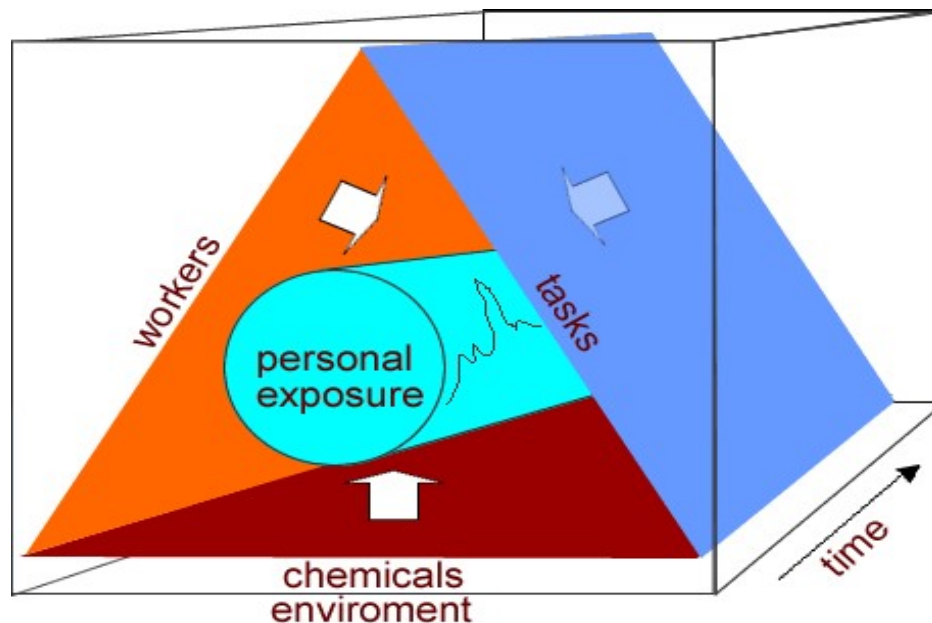
The Challenge for IH/Safety and Health Sensor Systems?



- We don't have a focused effort in developing video with sensors that will capture and play back exposure assessment projects
- We don't have a data analytics system that will help us understand exposure assessment profiles
- We don't have a data analytics system that will help us understand cost-effective control strategies
- We don't have a centralized data management system that will tell us where the problems are and how to prevent them in design – Prevention Through Design (PTD).

Occupational Exposures

- Exposures are a time event. Workers may experience different concentration levels at different time.
- Personal exposure levels are the interactive results of workers, handled materials, performed tasks and environment.



Patty's Industrial Hygiene
6th Edition, Vol 2 2012.
McGlothlin, Xu and Cole

NIOSH EVADE TOOL 2.0 – Note: Specific for Mining Industry.

The National Institute for Occupational Safety and Health (NIOSH)

Mining

Site Browser 🔍

Safety and Health Topics

Data & Statistics +

Tools & Publications -

Tools You Can Use

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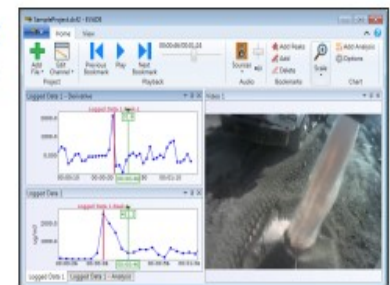


Keywords: [Data collection and recording](#) [Hazard recognition](#) [Hazard recording](#) [Hazards and exposures](#) [Personal monitoring](#)

Original creation date: August 2014

NOTE: Due to a switch in code signing certificates, it is recommended you uninstall EVADE and reinstall the latest version from this page. Prior versions will still automatically check for updates but you may get warnings that the provider is not trusted.

The Enhanced Video Analysis of Dust Exposures (EVADE) software program merges video files and logged data files, allowing the user to view them simultaneously to help identify exposure sources. Version 2.0 has been completely rewritten from the ground up. Based on the success of EVADE 1.0 and feedback from the EVADE user community, the function and capabilities have been expanded to make a more flexible and more powerful tool. It still remains the software component for Helmet-CAM. The Helmet-CAM procedure was developed by researchers at the National Institute for Occupational Safety and Health (NIOSH) and is a technique that uses a video camera worn by the worker to provide a visual record of the worker's activities concurrently with data collected by a real-time data logging aerosol monitor also worn by the worker.



Difference's Between: Enhanced Video Analysis of Dust Exposures (EVADE) and Video Exposure Monitoring (VEM)



EVADE

- Focused on Mining Industry: Mandate.
- Manual Bookmarks/Auto Peak
- Have to “cut and paste” data from CSV files resulting in possible human errors.
- Easier to share projects
 - One File
- Only does dust and noise

VEM

- Automatic Bookmarking/Highlight Reel
 - Peaks, Valleys, Equal to
 - Multiple Conditions over multiple data sets
- Excel File Support
 - Video and Data Files
- More Customizable Input
- Cross Platform
 - Windows, Mac, Linux
- Condition Template
 - Work in Progress
- Running Averages
- Multiple sensors: chemical, radiologic, biologic, physical.

- Examples of real-time instruments in VEM System:
 - Particulate real-time sampler
 - Solvent real-time sampler
 - Photo Ionization Detector – Volatile Organic Compounds
 - Noise dosimeter/ sound level meter
 - Radiation real-time detector
 - Infrared Detector
 - Ultra Violet Detection Meter
 - Heart-rate monitor
 - Temperature, humidity, vapor pressure, etc.

Evolution and Applications of VEM Technology

The Genesis of Video Exposure Monitoring (VEM)

Video Exposure Monitoring Research Pioneered by NIOSH Researchers* in 1985

- Company was batch processed products
- Video Exposure Monitoring for Real-time sampling was done using a:
 - Used Handheld Aerosol Monitor (HAM)
 - Apple computer was used to log airborne dust concentrations
 - VHS camera was used to record work activities.

**William Heitbrink and Mike Gressel*

Job where
NIOSH
researchers
studied batch
processing
of products.

This job involved
scooping of
powder from
a drum, weighing
the powder on
a scale, and putting
the bag of powder
in a receiving bin
located behind the
worker.



Drum Scooping Task



Summary of data what was modeled based on worker dust exposure. Notice how the dust exposure increases significantly after 35 bags of powder (about ½ of the total powder in the drum) have been scooped.



New workstation layout with $\frac{1}{2}$ height drum and slot exhaust to
Capture any residual dust from scooping task.



Worker scooping powder from a drum cut in half and raised to waist height. The bag scooping, weighing, depositing task are in line. Making it easier and more efficient (about 1/3 the cycle time as the original job layout)



Production flow from right to left





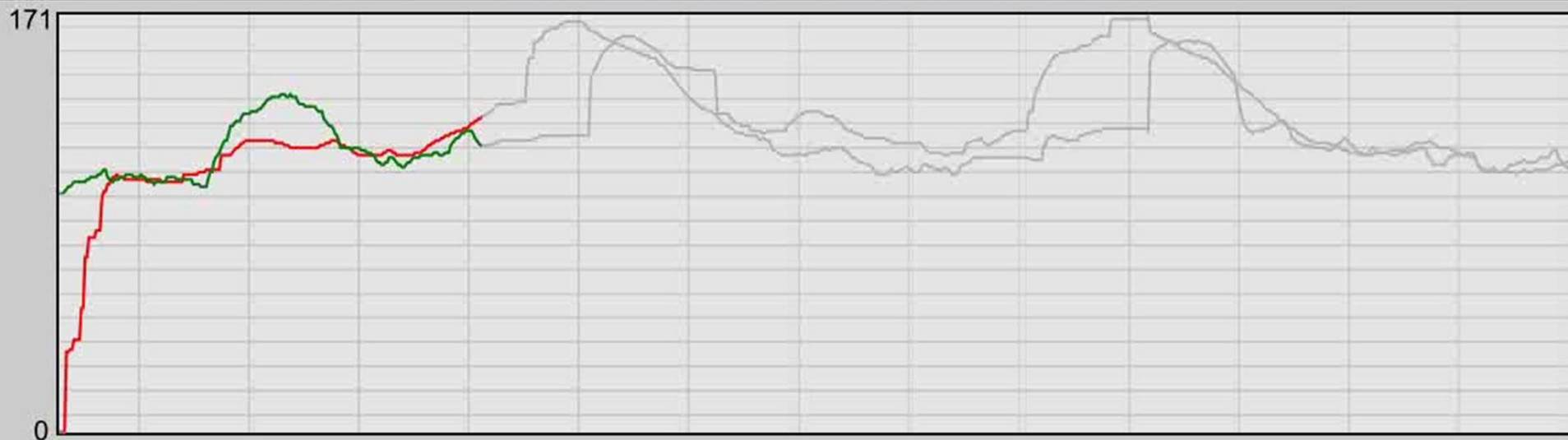






PURDUE
UNIVERSITY

09/07/2011
07:54:39



dyoCam1_20081201_141713.avi - AudioVideo - Paused

File Control Rate



2:18:35 PM (Sec: 62)



2:18:35 PM (Sec: 62)

Capture Details

Start Time 12/1/2008 2:17:13 PM
End Time 12/1/2008 2:19:04 PM
Duration 0 Days, 00:01:51 (666 sec)
Sample Rate 1
No. of Cameras 2
P1 Sensitivity 0.000
P2 Sensitivity 0.000

Playback Speed 1.00

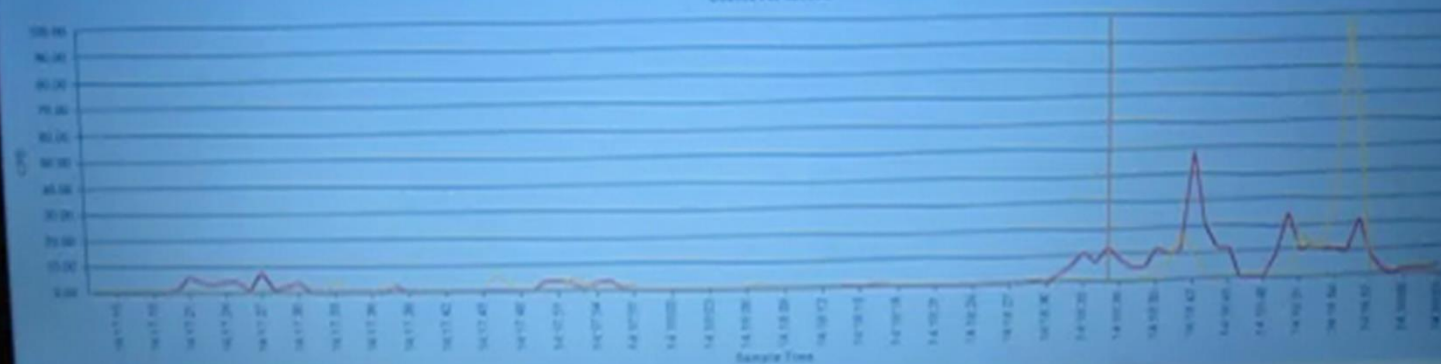
Play

Pause

Stop

Probe 1 Probe 2

Counts Per Second



Overlay

Counts Per Second

Statistical Summary

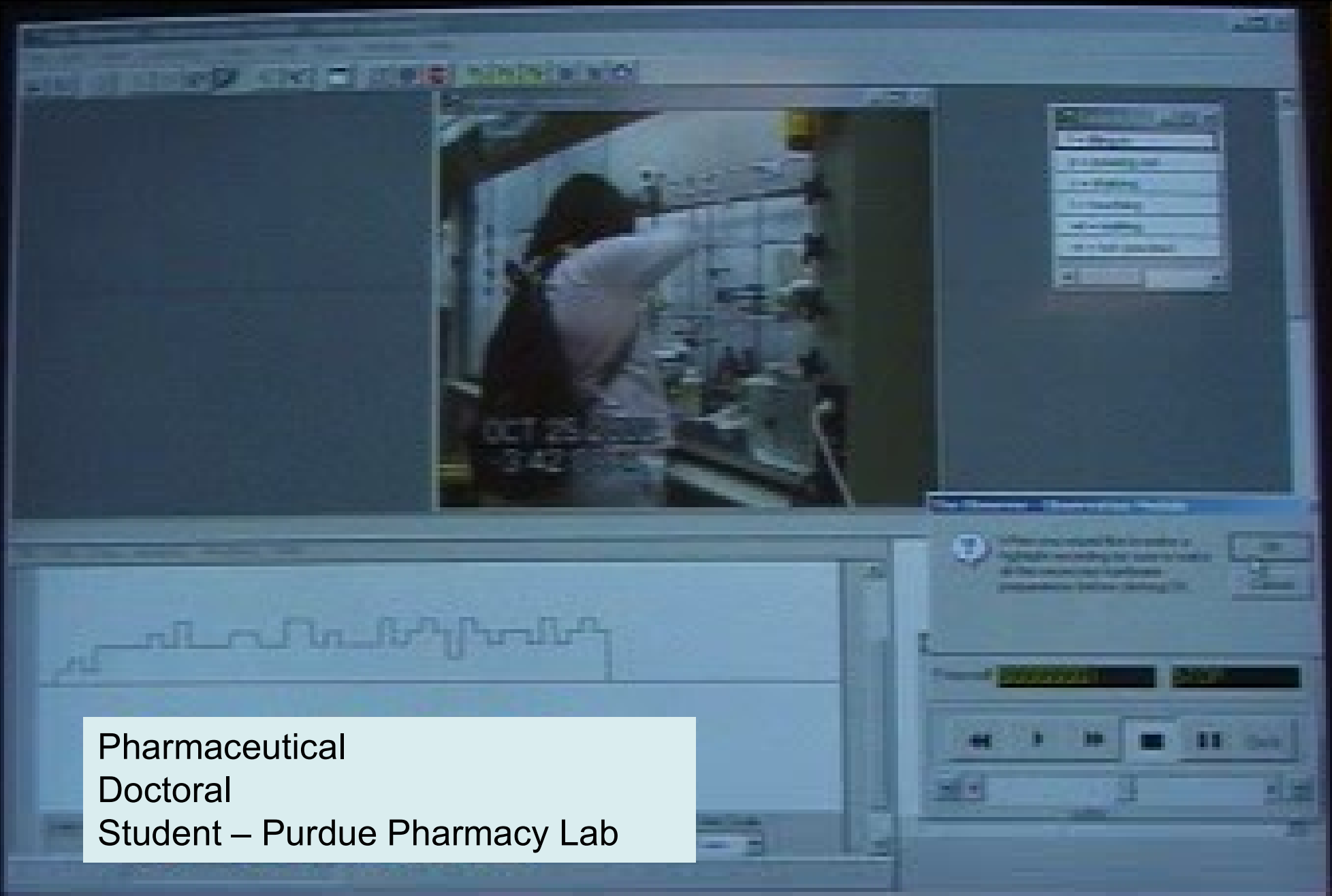
User Comments

User CF 1 0.00

User CF 2 1.00

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Pharmaceutical Laboratory Purdue University



Pharmaceutical
Doctoral
Student – Purdue Pharmacy Lab



Playback Panel

Playback Panel

InitPlayMode

Play/Pause

397, eid: 0

Event Markers

Clear All Markers

Scan Event IDs

☐ Set Current Markers

Scan Range

Upper Limit

0

Lower Limit

0

BACK

FWD

Marker 1 pouring lactose

Marker 2 mixer on

Marker 3 near table

Marker 4

Marker 5

Marker 6

Marker 7

Marker 8

AVI Player

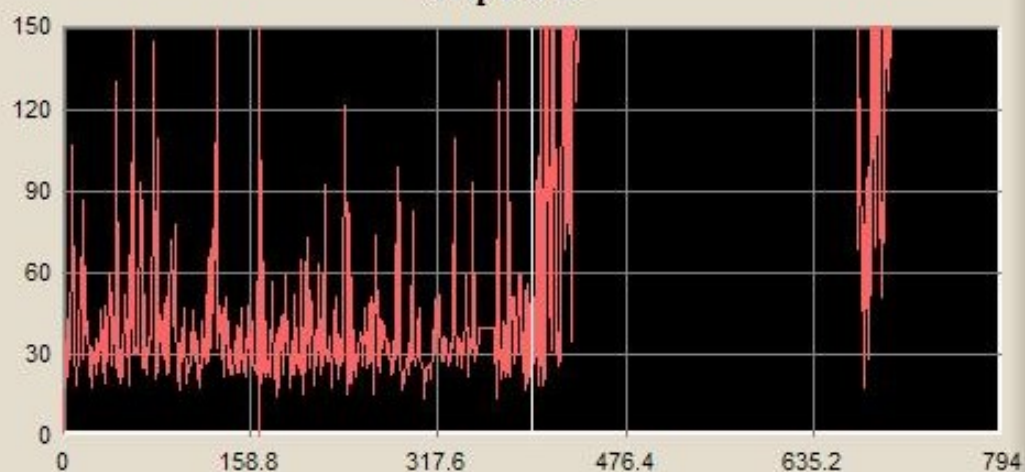


AVI Player



Graph Panel

Graph One



Instrument	Units	Mean	Std	Min	Max	Current
Particulates	ug/m3	1129.53	2224.91	0.00	20000.00	51.00
SPL	dbA					

Current study of Ecosciences Building on Boggo Rd., Dutton Park, Brisbane, Australia.



Representative set up for office indoor air quality monitoring using VEM.



Video Exposure Monitoring (VEM)[®] Indoor Air Quality

Assessment System
for collecting: TVOCs,
Particulates, CO₂,
Temperature, and
Humidity data.



**Phase II - “Pilot Study: Laboratory Evaluation of the
Iso-Gard Scavenging System, using
Bioluminescence Techniques, to control Airborne
Pathogens among Healthcare
Workers in the Post-Anesthesia Care Unit (PACU).”**

James McGlothlin*, MPH, Ph.D., CPE; Bruce Applegate**, Ph.D.
Josh L. Horton*, M.S., David Putt* Honors Pre-Med Student
School of Health Sciences*
Department of Food Sciences and Biological Sciences**
Purdue University

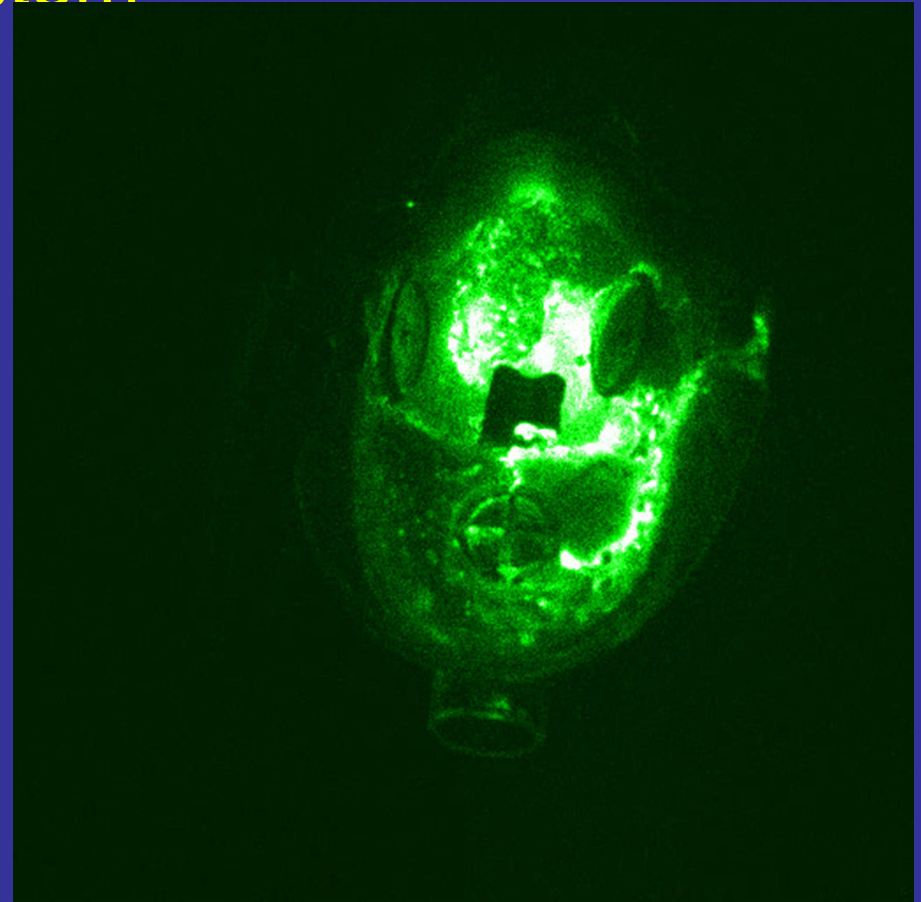
Bioluminescence as a tool to detect Pathogens

- The use of Bioluminescence will help determine where the escaped pathogens broke through the filter and identify containment by the scavenging system.
- Approximately three hundred years ago, when Robert Boyle first studied the use of Bioluminescence in the carcass of a chicken, he reported that the glowing chicken gave no heat, luminescence needed air, and pouring wine on the chicken decreased luminescence.
- The rapid detection of pathogens is necessary in healthcare settings, and bioluminescence-based methods are the most promising for the detection of bacteria.

Example of Bioluminescence of Iso-Gard Scavenging System



Mask in ambient light

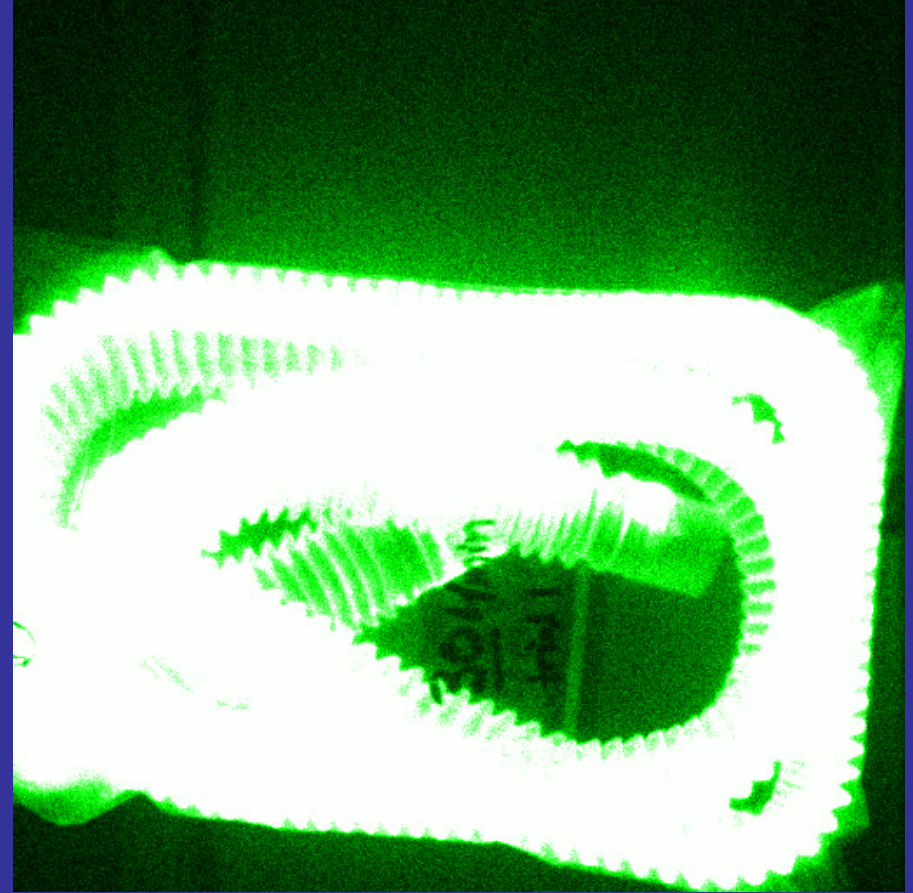


Mask imaged in dark showing bacteria pathogen (pseudomonas)

Example of Bioluminescence of Iso-Gard Scavenging System



Mask in ambient light



Mask imaged in dark showing bacteria pathogen

Pending Offerings



VEM Sensors can be attached to drones for remote sensing. May be helpful in fence line monitoring, or pre-designated flight paths to spot check for leaks or routine monitoring of industrial airborne contaminants.

*Correlate with
airborne particulate
levels, wind direction,
temperature,
humidity,
inside/outside.*

*Think about how this
may be used in the
for mapping silica
exposure in the
construction industry,
or for tracking
pathogens in the
healthcare industry.*



NIOSH Director Howard Imagines the Future of Industrial Hygiene

By Ed Rutkowski

- *San Antonio* (June 3, 2014) — The health effects of emerging manufacturing technologies and technological innovations in sampling practices will transform the industrial hygiene profession over the next 75 years, said NIOSH Director John Howard, MD, MPH, JD, LLM, in his AIHce 2014 General Session address this morning at the Henry B. Gonzalez Convention Center.
- “...The next era of exposure assessment may involve continuous sensing of the working environment,” Howard said. Industrial hygienists will soon have the ability to monitor chemical loads in workers’ bodies and determine how those exposures have altered the genome. In the next 75 years, Howard suggested that direct-reading instruments may allow workers to control their own exposures, and that industrial hygiene sampling may evolve to incorporate the use of sensors that continuously send exposure data to a central repository.”

Breaking News: VEM Game Changer

- **Costs matter.** New VEM Software and Hardware will reduce initial and operational costs from approximately \$3,000 dollars + Sensor (~ \$6,000 dollars) that may average to \$6,000 or more, to ~\$300 that includes an array of sensors.
- **Size matters.** The new VEM kit is portable, and like the “Tricorder”, gives you a lot of information in a small package.
- **Ease of operation matters.** VEM is easy to operate, and play back.
- **Analytics matter.** Real-time data and video can be uploaded to common spreadsheet software for detailed analyses for exposure assessment and control strategies.

Set up of portable-affordable VEM System

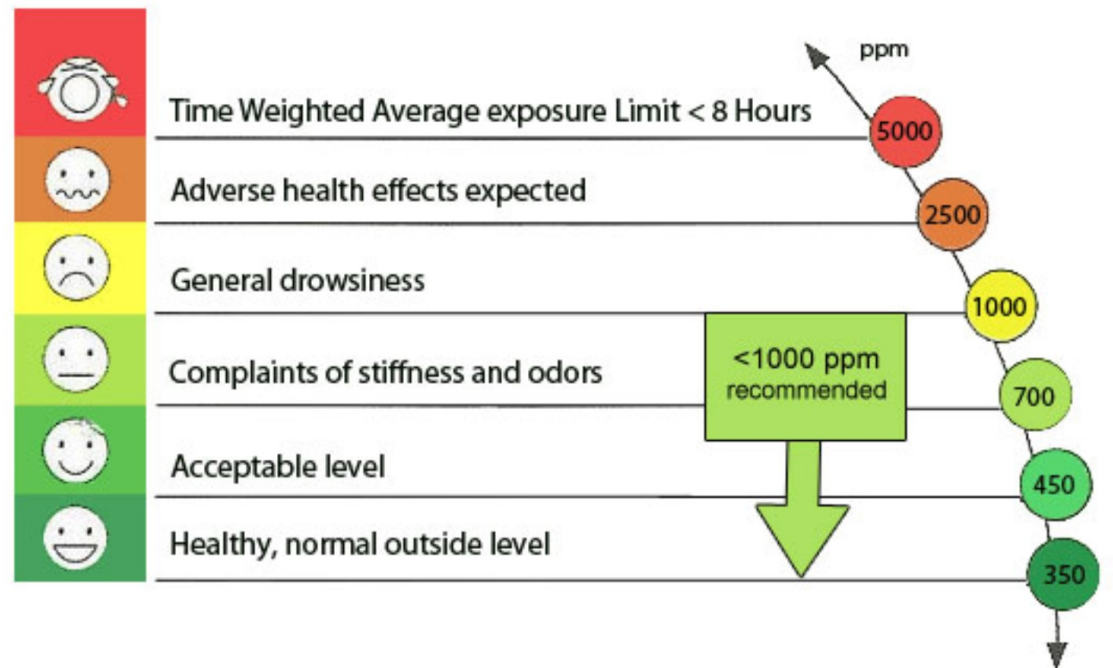
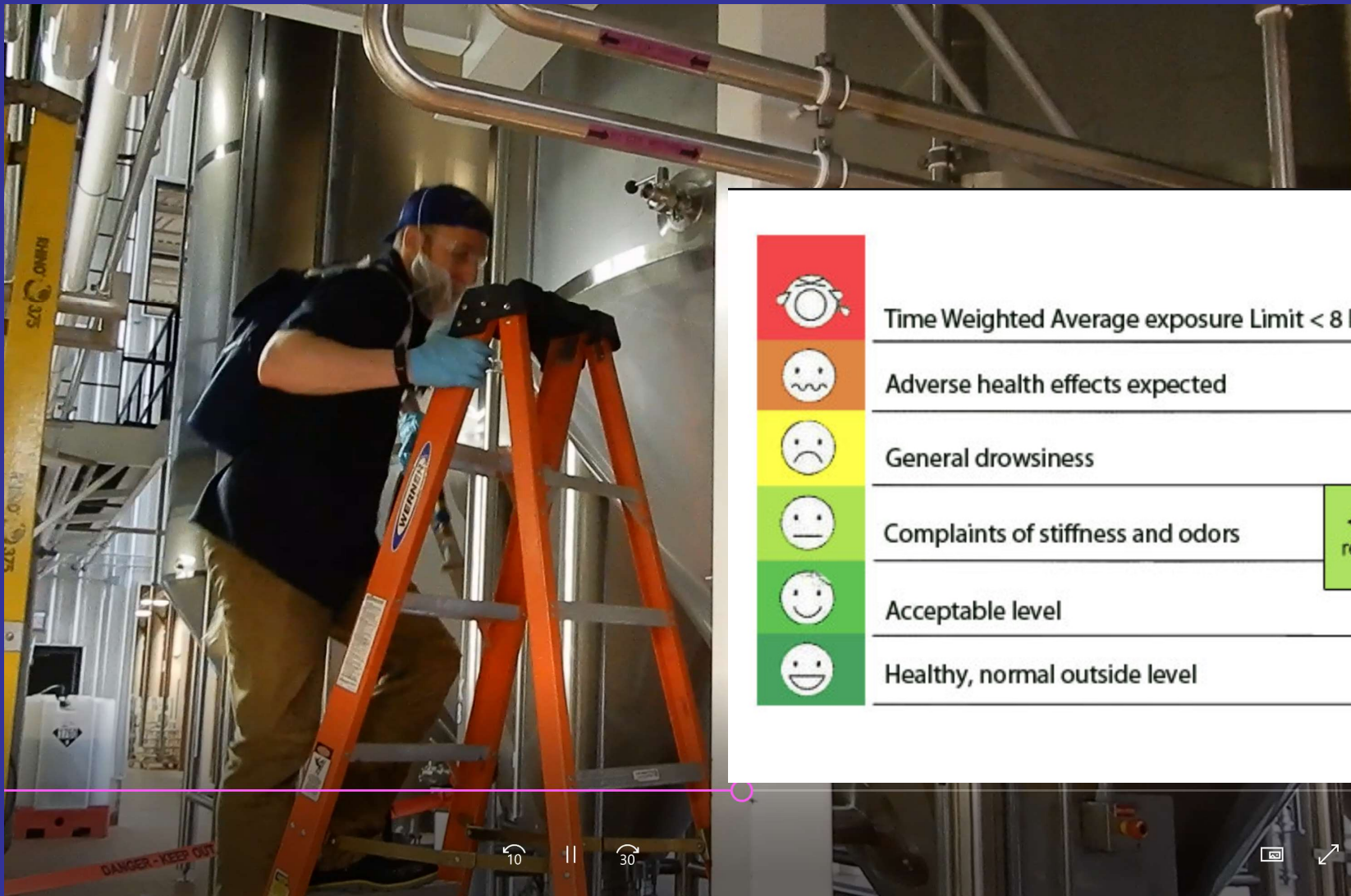


Special thanks to Kyle Fischer – B.S. (Computer Sciences), Purdue University

Portable-affordable VEM System



Water flushing tank that was purged with CO₂.



End of Part I. Questions?



Part II

- Demo and Training Session.
- Student engagement:
 - Assignment (to be turned in to Professor Huizen, with your name, at end of this session):
 - Please write down the key steps for setting up VEM for data collection
 - Please write down the key steps for VEM playback.

*Your notes will help both Professor Huizen and Dr. McGlothlin develop training instructions to set up VEM, collect data, and play back VEM for analysis.

Example for assignment

- Step 1: Inventory equipment needed for data collection
- Step 2: Connect components (identify what components) to Raspberry PI
- Step 3...
- .
- .
- .

Contact Information

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